CONDITIONED QUICKLIME FOR INJECTION TO A MOLTEN BATH OF A STEEL-MAKING VESSEL

FIELD OF THE INVENTION

The present invention is a method for refining steel by introducing conditioned quicklime, in particulate form, into an oxygen stream for injecting into a molten metal and slag bath of a steel-making vessel.

BACKGROUND OF THE INVENTION

In the process of converting iron to steel and of refining steel to obtain specific chemical compositions, it is known to provide a molten bath of the material being processed in a refining vessel in which chemical reactions are carried out to adjust the chemical composition of the material to that desired in the end-product.

Examples of refining vessels which are utilized include Basic Oxygen Furnaces, (BOF), Electric Arc Furnaces and Argon-Oxygen Decarburization vessels (AOD).

In the steel-making vessel, containing the molten metal, it is known to provide a covering of molten slag on the top surface of the molten metal. The slag layer provides a protective covering for the molten metal, as well as a source of material for reacting chemically with elemental components (such as phosphorus and sulfur), inclusions, and the like, found in the molten metal, in order to adjust their level of concentration. The molten slag is most often formed by reaction of the oxides of iron, silicon, manganese, and phosphorus, for example, with a slag-forming flux such as calcium oxide that is added to the furnace with the metallic charge.

The level of carbon in steel is an important consideration, as many of the properties of steel result from the carbon content of the steel. To remove carbon from the molten metal in a steel-making vessel it is well known to direct oxygen into the molten bath so as to combine

with the carbon, forming CO, which exits the molten metal as a gas, thus reducing the carbon content of the steel. The oxygen is most often blown into the molten metal with use of a lance so as to allow the oxygen to penetrate the layer of slag covering the molten metal. High pressure oxygen gas, directed with use of the lance, acts to stir the molten metal so as to promote the chemical reactions of the oxygen with the carbon, and also promote chemical reactions of other materials found in the molten metal with the slag layer on top of the molten metal.

During the oxygen blowing step it is often desired to add a slag-forming flux such as quicklime (CaO) to the steel-making bath. One method of adding CaO is to top charge the CaO on top of the molten slag. A large pebble CaO is often used, and it is added by dropping the CaO through an opening in the top of the refining vessel. Due to dust accompanying the pebble CaO, such practice usually has an impact on dust emissions that are captured by an air scrubbing system or a baghouse, and chemical reactions are delayed due to particle size and location of the charged material.

Another method for adding CaO to the molten metal and slag bath is to convey a particulate form of CaO with the oxygen being blown through the lance into the vessel. Although this method promotes better mixing and chemical reactions within the vessel, conveying the particulate form of CaO to the lance and through the lance itself has been difficult, as a particulate form of CaO is difficult to convey through conduits and the like.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a particulate form of CaO to a molten metal and slag bath contained in a steel-making vessel in a manner that presents the CaO in a particle size and in a location that is favorable for chemical reactions with the steel-making bath.

It is another object of the present invention to provide CaO to the molten metal and slag bath in a manner that does not increase the load on air scrubbing or baghouse operations.

SUMMARY OF THE INVENTION

The present invention is for use with a method of producing steel using a steel-making vessel, where lime is used as a flux material that is blown, from above, into a steel-making bath along with an oxygen stream. In such method of producing steel, it is a feature of the invention to provide a flux material composition of calcium oxide having a particle size of less than 250 mesh, which contains a flow aid material that is an organic siloxane, in an amount of less than 0.5 percent by weight of the calcium oxide, and injecting the flux material composition through a lance along with oxygen into the steel-making bath contained in the vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more readily apparent from the following description of a preferred embodiments thereof described in relation to the following drawings, wherein:

Fig. 1 is a cross-sectional view of a steel-making vessel having an oxygen injection lance for injecting oxygen into the steel-making bath;

Fig. 2 is a cross-sectional view of a lower portion of an oxygen lance for use with conditioned CaO of the present invention; and

Fig. 3 is a schematic diagram of a preferred process for producing a flux material of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a cross-sectional view of one example of a steel-making vessel in which molten metal, primarily iron, is refined to produce steel having a specified carbon content and acceptable levels of various other elements. As mentioned above, the composition of the molten metal is adjusted by causing chemical reactions to take place between the elements of concern and materials which are made to come into contact with those elements. Additionally, various materials for supplying elements that are deficient in the molten metal can be added, however such operation is not presently of concern.

The refining vessel depicted in Fig. 1 is a Basic Oxygen Furnace (BOF), it being just one example of a refining vessel suitable for use with the present invention. In Fig. 1, the vessel is indicated at 1 and at 2 a lance for injecting oxygen into the molten metal and slag bath is indicated. The molten metal is depicted at 3 and a layer of the molten slag, covering the surface of the molten steel, is indicated at 4.

The oxygen lance 2, in practice of the present invention, must incorporate means for introducing CaO into the stream of oxygen 5 entering the molten metal and slag bath. Fig. 2 is an example of a lance suitable for use in carrying out the present invention.

Fig. 2 depicts a lower end portion of an oxygen lance in which a particulate material is added to the oxygen stream. The lance of Fig. 2 is the subject of U.S. Patent No. 6,217,824, the contents of which are incorporated by reference, herein. In the lance, the particulate material and high-pressure oxygen is supplied through channel 6 for introduction into the molten metal and slag bath of the steel-making vessel.

In refining molten metal for the production of steel, time is of extreme importance as the actual refining step can be less than 15 minutes. Therefore, it is advantageous to have

any added material in a form that is conducive to reacting chemically with the steel-making bath. On the other hand, a particle size that is too small will add a burden to pollution control equipment if the particles are not captured by the bath. In the past, it has been found that an optimum particle size, in view of the chemical reactions, causes conveying problems in the channels of a lance and other conduits leading from a preparation or storage area to the lance. Small particles often plug conduits, and the like, and it is thought that van der Waals attraction is a factor in such plugging. The conditioned CaO of the present invention overcomes the conveying problems and provides a particulate material highly suitable for the chemical reactions in the steel-making bath.

The CaO of the present invention is prepared to have a preferred particle size of about 250 mesh (Tyler screen scale) or less, with only a small amount of fines that could contribute to the above-discussed pollution concerns. Such CaO particulate material is preferably prepared with use of a pulverizing mill and then sized with use of screening equipment. Introduction of the preferred size CaO into the steel-making bath enables the particles to be driven down toward the molten metal and slag bath for fast dissolution.

To improve the flowability of the CaO particles in the conduits and lance channels, the particles are mixed with a flow aid material to reduce the particle attraction that exists between adjacent particles. Such flow aid material causes adjacent particles to repulse each other so that they can flow with a low pressure carrier gas. The flow-aid material is added in an amount of less than 0.5 percent by weight of the CaO.

It has been found that injecting CaO of the preferred particle size provides a reduction in CaO consumption of from 5 % to 10 % during refinement of the molten steel. Other advantages include faster dissolution of the CaO, improved metallurgical benefits and shorter processing time for making a batch of steel.

Although the compound CaO is recited in describing the invention, it is known in the art that "high calcium quicklime" and dolomitic quicklime" are common types of "CaO" that

can be used as a fluxing material under various conditions within the reaction vessel, and the use of both types of quicklime are possible in practice of the invention.

The preferred flow-aid material is an organic siloxane, such as alkyl siloxane, including polydimethylsiloxane and polymethylhydrosiloxane, which has been used as a flow aid for pulverized lime.

It is believed that such material has been injected through tuyeres into the bottom of a QBOP furnace but not previously from above.

Fig. 3 depicts a preferred process for preparing the conditioned CaO of the invention. Tanks 7 and 8 are provided for storage of starting material of high calcium quicklime and dolomitic quicklime, respectively. The process is used to prepare the conditioned product as 100% high calcium quicklime flux material (in storage tank 9); 100% dolomitic quicklime flux material (in storage tank 10) or a blend of the flux materials (in storage tank 11).

In the process, either screw conveyor 12 or 13, or both are activated to convey the desired starting material to surge hopper 14. The surge hopper is used to feed pulverizing mills 15 and 16, which can include sizing screens and the like for obtaining the preferred particle size for further processing.

The pulverized material is conveyed through conduits 17 and 18, which are provided with means for coating the particles with the flow-aid material dispensed from a flow-aid dispenser tank 19A, through conduits 20 and 21. Additional flow-aid material is stored in a flow-aid transfer point tank at 19B. Following coating of the particles, the conduits continue to deliver the conditioned material to cyclones 22 and 23 for dust removal. Dust from cyclones 22 and 23 is conveyed to exhauster fans 15A and 16A which are associated with pulverizing mills 15 and 16, respectively. Following exit from the cyclones the conditioned fluxing material is directed to the proper storage tank (9, 10 or 11) with use of gates 24 and 25, for later use. In order to prevent contamination of air in the vicinity of the processing equipment dust collectors 26 and 27 are provided. Airlocks 28 are fluidly connected with

dust collectors 26 and 27 in order to control the flow of material between dust collectors 26 and 27 and surge hopper 14.

While specific materials, vessels, etc. have been set forth for purposes of describing embodiments of the invention, various modifications can be resorted to, in light of the above teachings, without departing from the Applicants' novel contributions; therefore in determining the scope of the present invention, reference shall be made to the appended claims.